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Iris Recognition Based on SIFT Features

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Introduction

- **Biometrics** provide a convenient way of user recognition:
  
  - no tokens or keys to carry (which can be lost)
  
  - no passwords to remember (which can be forgotten)
Introduction

- Iris recognition is regarded as one of the most **reliable** and **accurate** biometric recognition system available.

- Additionally, the iris is:
  - highly **stable** over a person’s lifetime.
  - **non-invasive** (externally visible organ).

- Explosion of interest in iris biometrics in recent years, with many applications developed.
Introduction

- Traditional iris recognition approaches approximates **iris boundaries as circles**.

- Transformation of the ring-shaped region of the iris to a **rectangular** image

- Features are then extracted from the **rectangular normalized iris pattern** (Gabor filters, log-Gabor filters, Gaussian filters, Laplacian-of-Gaussian filters, wavelet transforms, etc.)
Introduction

- **Reliable transformation** to polar coordinates is **crucial**:
  - Highly accurate **segmentation** needed
  - Problems with **non-cooperative or low quality data** (changes in the eye gaze, non-uniform illumination, eyelashes/eyelids occlusion, etc.)
Index

• This work is structured as follows:

Scale Invariant Feature Transformation (SIFT)

Database and protocol

Experimental results

Conclusions and Future Work
Scale Invariant Feature Transformation (SIFT)
Scale Invariant Feature Transformation (SIFT)

- Algorithm developed for general purpose object recognition*

- SIFT detects stable feature points of an object such that the same object can be recognized with invariance to illumination, scale, rotation and affine transformations

- Advantages for iris recognition

  - Transformation to polar coordinates or highly accurate segmentation is not needed

  - Due to its invariance to illumination, scale and rotation, it is expected to be feasible its use with unconstrained image acquisition conditions ->
    - increased user convenience
    - applicability to non-cooperative environments

Scale Invariant Feature Transformation (SIFT)

- **SIFT operation** for iris verification

**FEATURE EXTRACTION**
1. Scale space construction
2. Local extrema detection
3. Keypoint descriptor extraction

**FEATURE MATCHING**
4. Keypoint matching
5. Trimming of false matches
FEATURE EXTRACTION

1. Scale space construction

Substraction of consecutive images (DoG images)

Convolution with 2D \textit{gaussian operator} of increasing $\sigma$

Image downsampling (scale invariance)
FEATURE EXTRACTION

2. Local extrema detection (I)

- Detection of **local minimum or maximum** in the DoG images
- Comparison with its 8 neighbors in the current image and 9 neighbors in the two adjacent DoG images
FEATURE EXTRACTION

2. Local extrema detection (II)

- Removal of **unstable points** (two thresholds)
  - Points with **low contrast** (sensitive to noise)
  - Points **along an edge** (sensitive to viewpoint or lightning variation)

- **Orientation assignment** to each point (**rotational invariance**)
  - Histogram of **gradient orientations** around the point (36 orientation bins covering 360 degrees)
  - Detection of the histogram peak
Scale Invariant Feature Transformation (SIFT)

FEATURE EXTRACTION

3. Keypoint descriptor extraction

- Histogram of **gradient orientations**, relative to the major orientation of the point (8 orientation bins covering 360 degrees)
- Computation in 4x4 sub-regions around the point
- **Vector** with all the histogram entries (4x4x8=128 elements)
Scale Invariant Feature Transformation (SIFT)

FEATURE EXTRACTION

![Eye Feature Extraction Diagram]
FEATURE MATCHING
4. Keypoint matching

- Pairing of keypoints of two images based on the **Euclidean distance**
- **Matching of two points** if $d_1/d_2$ is sufficiently small
FEATURE MATCHING

4. Keypoint matching

- Pairing of keypoints of two images based on the **Euclidean distance**
- **Matching of two points** if $d_1/d_2$ is sufficiently small
- **Matching score** between two images = number of matched points
FEATURE MATCHING

5. Trimming of false matches

- Removing erroneous matching points using geometric constraints by limiting typical geometric variations to small rotations and displacements

- Not proposed in the original algorithm, adapted from *

Database and protocol

- **200 subjects from the BioSec Multimodal Database** (*
  - 2 acquisition sessions, office environment
  - Iris data with LG Iris Access 3000 sensor, image of 640x480 pixels
  - 200 individuals X 2 eyes X 4 images/eye x 2 sessions = 3200 images

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Database and protocol

- **Protocol**
  - 50 individuals for training, 150 for testing
  - Each eye considered as a different user (total 400 users)

  - **Genuine matchings** = the 4 samples of the first session against the 4 samples of the second session
  - **Impostor matchings** = the 4 samples of the first session against 1 sample of the second session of the remaining individuals

  - **Images segmented automatically** using circular Hough transform + manual correction of incorrect images (to avoid bias in the performance due to incorrectly segmented images)

Database and protocol

- **Baseline iris matcher (*)**
  - For comparison with the proposed SIFT matcher
  - 1D implementation of the Daugman algorithm
  - Based on transformation to polar coordinates and Log-Gabor wavelets
  - Output of filtering is phase quantized to binary level
  - Matching using the Hamming distance

Experimental Results
Results

- **Optimization of SIFT parameters (training set)**
  - **Threshold $D$** for **discarding low contrast points** (the one proposed in the original paper discards most of the useful points in the iris region)
  - **Rotation and displacement tolerances** for **trimming of false matches**
  - Finding out the optimal combination of parameters (minimization of the EER in the training set):

<table>
<thead>
<tr>
<th>$D$</th>
<th>$\varepsilon_\theta$</th>
<th>$\varepsilon_\ell$</th>
<th>EER</th>
</tr>
</thead>
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<tr>
<td>0.25</td>
<td>-</td>
<td>-</td>
<td>36.85%</td>
</tr>
<tr>
<td><strong>0.25</strong></td>
<td>18</td>
<td>14</td>
<td><strong>9.68%</strong></td>
</tr>
<tr>
<td>0.5</td>
<td>14</td>
<td>16</td>
<td>9.92%</td>
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<tr>
<td>0.75</td>
<td>18</td>
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</tr>
<tr>
<td>1</td>
<td>16</td>
<td>14</td>
<td>14.03%</td>
</tr>
</tbody>
</table>

D=0.25/255
EERmin=9.68%
Results

- RESULTS

**DEVELOPMENT SET**
- SIFT – EER=9.68%
- Baseline – EER=4.64%

**TEST SET**
- SIFT – EER=11.52%
- Baseline – EER=3.89%
- Fusion – EER=2.96%
Conclusions & Future Work
Conclusions

- Proposal of the SIFT operator for iris feature extraction and matching
  - Analysis of the influence of different SIFT parameters
  - Inclusion of an step for trimming of false matches

- Although the performance is (still) below popular approaches, we demonstrate its **feasibility** for iris recognition, as well as its **complementarity in the fusion**

- The SIFT operator:
  - Does not need transformation to **polar coordinates** or highly **accurate segmentation**
  - Due to its invariance to illumination, scale and rotation, it is expected to be feasible its use with **unconstrained image acquisition conditions**
Future Work

- Inclusion of *eyelids/eyelashes* detection

- Inclusion of *local quality measures* (*) to weight the contribution of each point to the matching score

- Applicability to datasets acquired in *unconstrained conditions* (**)

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